

# Distributed Leak Detection System Using Structure-Borne Noise, Phase I

Completed Technology Project (2007 - 2008)



## Project Introduction

Manned spacecraft are vulnerable to air leaks caused by micrometeorite and space debris impact. The ability to detect and quickly locate and mitigate a pressure vessel breach is critical to the safety of any long duration spacecraft, such as the International Space Station or a proposed lunar base or mission to Mars. Current NASA protocol for finding a spacecraft leak uses a handheld ultrasonic directional microphone, similar to those widely deployed industrially, to detect the 40 kHz airborne ultrasonic hiss generated by the downstream leak turbulence. However, known limitations exist regarding the use of airborne ultrasonic emissions for locating leaks in the spacecraft environment because the downstream side of the leak occurs into the vacuum of space, creating reduced leak noise inside the pressure vessel. Blockages of the transmission of airborne ultrasonic energy by structural components, avionics, and equipment racks also limit the detection range of such systems. An alternative approach that we propose is to monitor the spacecraft structure itself---the pressure vessel skin---for leak-generated surface-borne ultrasound by means of a flexible and modular electronics package with fully integrated surface sensor arrays, data acquisition electronics, and radio frequency communication capabilities.

## Anticipated Benefits

Beyond the direct application of the proposed technology for detecting leaks to vacuum in pressurized space vehicles, significant opportunities exist within the more broad application field of applying PZT sensor arrays to Nondestructive Evaluation. Opportunities for the proposed technology in the areas of Military Weapons Systems Monitoring, Industrial / Chemical Processing Facility Monitoring, and Commercial Aircraft Test and Evaluation will be pursued, among others. The NASA program with the most risk due to Micro-meteor / Orbital Debris (MMOD) is currently the International Space Station, due to the prolonged exposure on-orbit and the large surface area of the orbiting habitat. For this reason, it is particularly important that the system be able to be installed easily in a retrofit manner behind closeout blankets in easily accessible areas. Additionally, it must be fully self-contained, requiring only minimal data interfaces to the ISS for data transfer to the crew and ground controllers. Although the risk to the Shuttle from MMOD is largely considered to be due to the RCC panels of the Wing Leading Edge and Nose Cone, significant risk is still present in the pressurized portions of the vehicle. Additionally, such a system could be used to monitor for leaks in the airlocks and other sealed vacuum interfaces. As part of the Orion Program, NASA will attempt to increase safety by an order of magnitude over the current Shuttle vehicle. MMOD is a major source of risk for the Shuttle, and will continue to be a risk for the Orion, despite its improved MMOD shielding. The proposed system could likely be fully integrated with the Orion avionics systems, providing continuous monitoring of the entire structure while requiring only minimal vehicle resources and launch mass, as well as very little maintenance.



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## Organizational Responsibility

### Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

### Lead Center / Facility:

Johnson Space Center (JSC)

### Responsible Program:

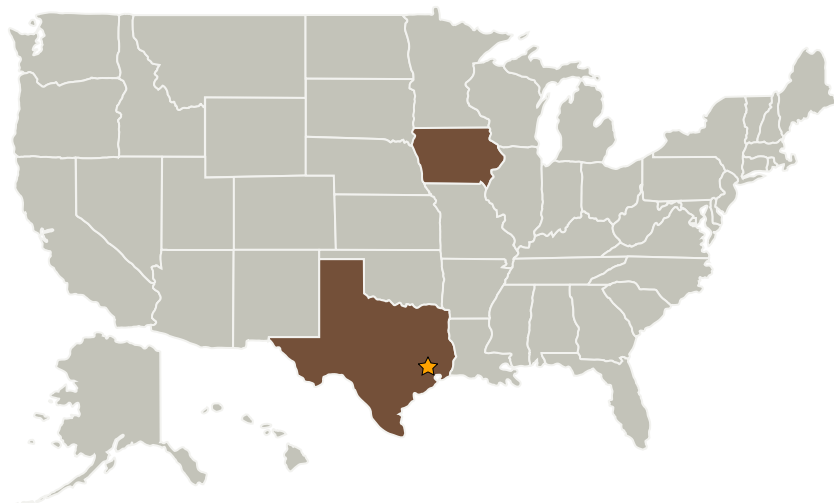
Small Business Innovation Research/Small Business Tech Transfer

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## Primary U.S. Work Locations and Key Partners



| Organizations Performing Work | Role                    | Type  | Location       |
|-------------------------------|-------------------------|---|----------------|
| ★ Johnson Space Center(JSC)   | Lead Organization       | NASA Center                                     | Houston, Texas |
| Invocon, Inc.                 | Supporting Organization | Industry<br>Veteran-Owned Small Business (VOSB) | Conroe, Texas  |
| Iowa State University         | Supporting Organization | Academia  | Ames, Iowa     |

## Primary U.S. Work Locations

|      |       |
|------|-------|
| Iowa | Texas |
|------|-------|

## Project Management

### Program Director:

Jason L Kessler

### Program Manager:

Carlos Torrez

### Project Manager:

George F Studor

### Principal Investigator:

Jonathan Summers

## Technology Areas

### Primary:

- TX10 Autonomous Systems
  - TX10.2 Reasoning and Acting
    - TX10.2.5 Fault Diagnosis and Prognosis